NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

POND SEALING OR LINING - FLEXIBLE MEMBRANE, (NO.)

CODE 521A

DEFINITION

A manufactured hydraulic barrier consisting of a functionally continuous sheet of synthetic, or partially synthetic, flexible material.

PURPOSE

To control seepage from water and waste impoundments for water conservation and environmental protection.

CONDITION WHERE PRACTICE APPLIES

On ponds and water storage structures that require treatment to control seepage rates within acceptable limits.

On waste storage and waste treatment facilities built in or of excavated earth, and which require treatment to prevent the migration of contaminants from the site.

MINIMUM CRITERIA FOR MEMBRANES	
Type	**Limiting Parameter**
HDPE	40 mil thickness
LLDPE	40 mil thickness
PVC	30 mil thickness
GCL	0.75 lb./sq. ft. (bentonite)
EPDM	40 mil thickness

HDPE = High Density Polyethylene
LLDPE = Linear Low Density Polyethylene
PVC = Polyvinyl Chloride
GCL = Geosynthetic Clay Liner
EPDM = Synthetic Rubber

CRITERIA

Structures to be lined shall have been constructed to meet all applicable NRCS standards. All inlets, outlets, ramps, and other appurtenances may be installed before, during, or after the liner placement, but shall be done in a manner that does not damage or impair the proper operation of the liner.

All flexible membranes shall be certified by the manufacturer to be suitable for the intended use.

Design of the flexible membrane shall be in accordance with manufacturer recommendations. All flexible membrane installations shall meet the material and installation requirements of the plans and specifications provided for each installation, and shall be certified by the installer.

Select soil materials shall be used as cover for liners where required for the proper performance, protection, and durability of the installation. Cover soils shall not contain sharp, angular stones, or any objects that could damage the liner. Maximum allowable particle size of soil cover material shall be 3/8 in. (10 mm), unless the liner is cushioned by a needle punched, non-woven geotextile. Cover materials shall be stable under all operational and exposure conditions.

Subgrade preparation shall conform to manufacturer recommendations. Subgrade materials shall not contain sharp, angular stones, or any objects that could damage the liner or adversely impact its function.

All structures shall be fenced to protect the liner from damage and for the safety of humans, livestock, wildlife, and pets.

NRCS, AL
March 2002

Manufacturer recommendations shall be followed with regard to protection from weather and exposure.

If venting is used, manufacturer recommendations shall be followed regarding vent type and spacing.

CONSIDERATIONS

Venting should be considered if gas build up under the liner is anticipated.

If high water tables could adversely affect the proper functioning of the facility, interceptor or relief type drainage systems should be considered to control uplift pressures.

Designs should include provisions for protection from damage during pond draining or pump out.

If agitation equipment is used, installation of a concrete pad in the area of the equipment should be considered.

For uncovered liners, consider placement of wooden boards on the liner slope to allow small animals escape routes from the water surface.

PLANS AND SPECIFICATIONS

Plans and specifications shall be prepared for specific field sites in accordance with this standard and shall describe the requirements for applying the practice to achieve its intended uses.

As a minimum, plans and specifications shall include:

- Plan view of layout
- Foundation preparation requirements
- Type and thickness of liner
- Method of installation
- Method to protect liner
- Structural details
- Drain and vent details
- Material quantities

OPERATION AND MAINTENANCE

A plan for operation and maintenance of the liner shall be prepared. The plan should address repair of the liner, exclusion of animals and equipment from the liner, protection during filling, agitation, and pumping operations.

CONSTRUCTION SPECIFICATION
NATURAL RESOURCES CONSERVATION SERVICE

521A - POND SEALING OR LINING - FLEXIBLE MEMBRANE

SCOPE

The work shall consist of furnishing and installing a flexible membrane pond lining along with necessary appurtenances as shown on the drawings and described in the specifications. Construction operations shall be carried out in such a manner that erosion, water, air, and noise pollution will be minimized and held within legal limits as established by state regulations.

Construction of the pond lining shall be according to plans furnished or approved by the Natural Resources Conservation Service. Any deviation from the approved drawings and specifications must be approved by the engineer prior to construction.

MATERIAL

Unless otherwise specified, the liner material shall conform to the following requirements and to the requirements shown on the drawings.

HDPE AND LLDPE

HDPE and LLDPE liners shall be manufactured to be suitable for use in either exposed or buried conditions. Unless otherwise specified, gasket material shall be neoprene, closed cell medium, 0.25 inch thick, with adhesive on one side, or other gasket material as approved by the liner manufacturer. Metal battens shall be 0.25 inch thick by 2 inches wide stainless steel. Clamps shall be 0.5-inch-wide stainless steel. Embed channel shall have the same properties as the liner. Sealant shall be General Electric Silicone, RTV 103, or equivalent. The HDPE or LLDPE liner shall be manufactured from virgin polymer material and unless otherwise specified shall meet the property values specified under Tables 1 through 4 as applicable.

GCL

The GCL is composed of a layer of high shrink-swell sodium bentonite sandwiched between two layers of geotextile. The GCL material shall be manufactured by one of the following processes:

- Needle punched process by which the bentonite is encapsulated between the geotextile layers by a mechanical bonding process without the use of any chemical binders or adhesive, or
- Lock stitched to provide internal shear strength and the integrity and consistency to the thickness and unit weight of the material.

The bentonite shall have the following base properties:

- A minimum of 0.75 pound per square foot of high shrink/swell sodium bentonite at 12 percent moisture as determined by ASTM D 5993. If the liner material is manufactured at higher moisture content, it shall still meet the above requirements when adjusted to the 12 percent moisture level.
- Swell index - minimum 24 ml per 2 grams as determined by ASTM D 5890.
- Fluid loss - maximum 18 ml as determined by ASTM D 5891.

The GCL shall have an index flux value no larger than 1×10^{-8} m/s as determined by ASTM D 5887.

PVC

PVC membranes shall meet the requirements of Table 5 unless otherwise specified. Gasket material, adhesives, sealants, and other materials shall be compatible with the liner material as approved by the manufacturer.

EPDM

EPDM shall meet the requirements of Table 6 unless otherwise specified. Gasket material, adhesives, sealants, and other materials shall be compatable with the liner mateial as approved by the manufacturer.

SHIPPING AND STORAGE

Liner materials shall be transported to the site and stored in a manner to prevent damage to

the material. Appropriate equipment shall be provided for handling the liner on site. A core bar in combination with a spreader bar or a forklift with stinger attachment shall be used for handling rolls. The rolls shall be stored on a flat, smooth surface and covered to keep dry and provide protection to the liner material. GCL's shall not be allowed to contact any moisture prior to placement.

SUBGRADE PREPARATION

Subgrade soil shall be compacted to provide a firm, unyielding foundation for the liner. All surfaces shall be smooth, free of foreign and organic material, rocks larger than 3/8 inch, any angular rocks, and any sharp objects. All projections shall be removed, crushed, or pushed into the surface with a rubber-tired or smooth-drum roller. Standing water or excessive moisture shall not be allowed. GCL shall only be placed on a dry subgrade. If needed, an effective soil sterilant shall be applied to the subgrade at the rate recommended by the manufacturer.

ANCHOR TRENCH

The anchor trench shall provide permanent anchoring for the liner and shall be in accordance with the drawings. The trench shall be excavated according to a daily schedule for liner installation. It shall be backfilled incrementally as needed. Backfill soil shall be compacted by rolling with rubber-tired equipment or a manually directed power tamper to provide a stable anchor trench for the liner. Unless otherwise specified, the anchor trench shall be 1.5 feet wide and 1.5 feet deep.

LINER PLACEMENT

Installation procedures shall be according to the manufacturer's recommendations. Placement of GCL shall be limited each day to an area that can be fully installed, including proper seaming, covering around appurtenances and placement of cover soils. GCL shall not be placed in the rain or fog or at times of impending precipitation. Replace any GCL that has begun to hydrate before cover soil can be placed. Placement of rubber and plastic membranes shall be limited each day to an area that can be placed, seamed, and secured by the end of the work day. Placement of rubber and plastic membranes shall not be done during fog, rain, or excessive winds. Rubber and plastic liners shall be loosely laid with sufficient slack (about 2 percent) to accommodate thermal expansion and contraction during construction. Orientation of panels, seams, and overlaps shall conform to the manufacturer's recommendations and to the drawings. Attachment of the liner to and sealing around pipes and other appurtenances shall be according to the drawings and manufacturer's recommendations.

SEAMING

GENERAL

Seams shall be dried and cleaned of dust, dirt, and other foreign material prior to seaming operations. Upslope panels shall overlap downslope to provide a shingle effect. Seams shall extend to the outside edge of panels to be placed in anchor trenches.

HDPE and LLDPE

The primary method of seaming shall be hot wedge fusion welding. Fillet extrusion welding shall be used for repairs, T-seams, and detail work. Hot wedge welding shall be accomplished by a double-wedge fusion welder that produces a double track weld. Extrusion welding equipment shall be approved by the liner manufacturers. Liner panels shall have a minimum overlap of 4 inches for hot wedge welding and 3 inches for extrusion welding. Liner shall not be placed when air temperatures are less than 50° Fahrenheit. All seaming operations, seam testing, and seam repair shall be in accordance with the manufacturer's recommendations and standard industry practices.

PVC

Field seams shall be welded using thermal or chemical fusion welding. All field seaming shall be in accordance with the manufacturer's recommendations. Panels shall be overlapped a minimum of 4 inches at the seam location. Special precautions, as recommended by the manufacturer, shall be taken for seam welding if the ambient sheet temperature is above 105° F. Seam welding shall not be conducted if the ambient sheet temperature is below 40° F or above 140° degrees F.

Chemical fusion agent shall be applied to both panels by a squeeze bottle or paint brush. The width of application shall be a minimum of 2 inches. Light pressure shall be applied by an acceptable roller to force intimate contact between the panels. Excess agent extruded from the seam shall be removed immediately.

Thermal welds shall be accomplished with a single or dual track hot wedge system. The seam width shall be a minimum of 1 inch. Welding equipment and accessories shall be approved by the manufacturer. Each welder

shall be calibrated at the beginning of each seaming period, to produce acceptable seams for the site conditions.

GCL

The GCL panels are to be placed so that the seams are parallel to the direction of the slope. This is also true in the corners. All seams parallel to the slope direction shall be overlapped a minimum of 6 inches. End-of-roll seams shall be located at least 3 feet from the toe or crest of the slope. Seams at the base of the slope shall be a minimum of 6 feet from the toe.

When a roll-end seam or joint occurs on a slope, construction adhesive shall be used in a lap area, with the overlap increased to 2 feet and shingled in the direction of the slope. All seam areas, or runs, shall be augmented with granular bentonite of the same quality of that encapsulated in the liner to ensure seam integrity. Granular bentonite shall be dispersed evenly from the panel edge to the lap line at a minimum rate of 1 pound per 4 linear feet continuously along all seams or overlap areas. Construction adhesives may be used on seams to keep panels in contact during backfill operations if necessary.

For any penetrations or structures the liner will contact, a small notch shall be cut or dug against the edge of the area. The liner shall be brought up to the appurtenance and trimmed to fit into the notch. Granular bentonite or a mixture of 1 part bentonite to 4 parts soil (by volume), blended dry, shall be placed into the bottom half of the notch. The liner shall then be inserted into the notch, with the remaining area in the notch filled with the granular bentonite or the 1 to 4 mixture, and compacted.

EPDM

Seams shall be overlapped a minimum of 4 inches. Seams shall be overlapped and glued with a 6-inch cover strip glued over the seam, or shall be overlapped and bonded using a double faced inseam tape. The primer (glue) must flash (solvent volatilizes and becomes sticky) before the two surfaces are placed in contact. Manufacturer's recommendation shall be followed for completing the seams.

SEAM TESTING

All seams of plastic and rubber membranes shall be tested. Double-wedge-fusion seams shall be air pressure tested. Extrusion welded seams shall be vacuum-box tested. Single track seams shall be tested with an air lance with 50 psi pressure. All tests shall be performed according to the manufacturer's recommendations.

REPAIRS

All defective liner areas, bad seams, tears, and punctures shall be repaired and tested before the installation is completed and before any cover soils are placed.

PLACEMENT OF COVER SOILS

Where a soil cover is specified, the soil and its placement method shall be in accordance with the drawings and shall conform to this specification and the liner manufacturer's recommendations. Cover soils shall not contain angular rocks or sharp objects that could damage the liner. Placement shall be by a loader or bulldozer. No construction machinery shall be allowed to drive directly on the liner.

A minimum of 12 inches of cover soil is required under the tracks or tires of construction equipment, with ground pressures of less than 5 pounds per square inch, before operating on the liner. The depth of cover soil shall be proportionally higher for heavier equipment. In frequently trafficked areas or roadways, a minimum cover thickness of 2 feet is required. The soil cover on all slopes shall be pushed up (not down) the slopes to prevent any downhill stress on the liner material. Avoid any sharp turns and quick starts or stops that could pinch or shift the liner.

Cover material shall be placed on plastic and rubber liners during the cool times of the day or at night to prevent liner folds.

PLACEMENT OF CONCRETE

Concrete placement for ramps and other appurtenances shall be in accordance with the drawings and specifications. All reinforcement steel shall be placed on flat-footed plastic rebar chairs. All rebar splices shall be fully tied to avoid loose ends. On slopes, concrete shall be placed from the bottom of the slope to the top and have a low slump to prevent sloughing down slope during placement. Only plastic shovels and internal vibrators shall be used to place concrete. Metal shovels and rodding are not allowed. Concrete forms shall be held in place by methods that avoid damaging the liner.

Table 1. Requirements for smooth HDPE liner.

Property	Test methods	Requirements* --nominal thickness-- 40 mil	60 mil
Density, g/cc	ASTM D 1505	0.940	0.940
Tensile Properties	ASTM D 638 (type IV at 2 in/min)		
yield stress, lb/in		84	126
break stress, lb/in		152	228
yield elognation, %		12	12
break elongation, %		560	560
Tear resistance, lb	ASTM D 1004	28	42
Puncture resistance, lb	ASTM D 4833	72	108
Carbon black content, %	ASTM D 1603	2-3	2-3
Carbon black dispersion	ASTM D 5596	Cat 1-2	Cat 1-2
Seam properties	ASTM D 4437 (1 in wide at 2 in/min)		
shear strength, lb/in		80	120
peel strength, lb/in**		52/FTB	78/FTB

* All values, unless specified otherwise, are minimum average roll values as reported for the test method.

** Film tear bond: A failure of one of the bonded sheets by tearing prior to complete separation in the bonded area.

Table 2. Requirements for textured HDPE liner.

Property	Test methods	Requirements* --nominal thickness-- 40 mil	60 mil
Density, g/cc	ASTM D 1505	0.940	0.940
Tensile Properties	ASTM D 638 (type IV at 2 in/min)		
yield stress, lb/in		84	126
break stress, lb/in		60	90
yield elognation, %		12	12
break elongation, %		100	100
Tear resistance, lb	ASTM D 1004	28	42
Puncture resistance, lb	ASTM D 4833	60	90
Carbon black content, %	ASTM D 1603	2-3	2-3
Carbon black dispersion	ASTM D 5596	Cat 1-2	Cat 1-2
Seam properties	ASTM D 4437 (1 in wide at 2 in/min)		
shear strength, lb/in		80	120
peel strength, lb/in**		52/FTB	78/FTB

* All values, unless specified otherwise, are minimum average roll values as reported for the test method.

** Film tear bond: A failure of one of the bonded sheets by tearing prior to complete separation in the bonded area.

Table 3. Requirements for smooth LLDPE liner.

Property	Test methods	Requirements* --nominal thickness-- 40 mil	60 mil
Density, g/cc	ASTM D 1505	0.915	0.915
Tensile Properties	ASTM D 638 (type IV at 2 in/min)		
yield stress, lb/in		60	94
break stress, lb/in		170	255
yield elognation, %		13	13
break elongation, %		800	800
Tear resistance, lb	ASTM D 1004	22	33
Puncture resistance, lb	ASTM D 4833	68	102
Carbon black content, %	ASTM D 1603	2-3	2-3
Carbon black dispersion	ASTM D 5596	Cat 1-2	Cat 1-2
Seam properties	ASTM D 4437 (1 in wide at 2 in/min)		
shear strength, lb/in		58	90
peel strength, lb/in**		50/FTB	90/FTB

* All values, unless specified otherwise, are minimum average roll values as reported for the test method.

** Film tear bond: A failure of one of the bonded sheets by tearing prior to complete separation in the bonded area.

Table 4. Requirements for textured LLDPE liner.

Property	Test methods	Requirements* --nominal thickness-- 40 mil	60 mil
Density, g/cc	ASTM D 1505	0.915	0.915
Tensile properties	ASTM D 638 (type IV at 2 in/min)		
yield stress, lb/in		58	87
break stress, lb/in		80	120
yield elognation, %		13	13
break elongation, %		350	350
Tear resistance, lb	ASTM D 1004	23	35
Puncture resistance, lb	ASTM D 4833	68	102
Carbon black content, %	ASTM D 1603	2-3	2-3
Carbon black dispersion	ASTM D 5596	Cat 1-2	Cat 1-2
Seam properties	ASTM D 4437 (1 in wide at 2 in/min)		
shear strength, lb/in		53	79
peel strength, lb/in**		44/FTB	66/FTB

* All values, unless specified otherwise, are minimum average roll values as reported for the test method.

** Film tear bond: A failure of one of the bonded sheets by tearing prior to complete separation in the bonded area.

Table 5. Requirements for PVC Liner.

Property	Test methods	Requirements* --nominal thickness-- 30 mil	40 mil
Specific Gravity	ASTM D 792	1.2	1.2
Tensile Properties	ASTM D 882		
Breaking Factor, lb/inch(MD and XD)		73	97
Elongation at break %		350	400
Tear Resistance, lb	ASTM D 1004	8.5	10.5
Low Temperature Brittleness, °C	ASTM D 1790	-29	-29
Dimensional Stability, % (maximum)	ASTM D 1204	3	3
Hydrostatic Resistance, lbs./in^2	ASTM D 751 Method A	100	120
Seam Properties	ASTM D 6392/D 6214		
shear strength, lb/inch		58.4	77.6
peel strength, lb/inch		15	15

*All values, unless specified otherwise, are minimum average roll values as reported for the test method.

MD = Machine Direction

XD = Cross-Machine Direction

Table 6. Requirements for EPDM Liner.

Property	Test methods	Requirements* --nominal thickness-- 45 mil	60 mil
Specific Gravity	ASTM D 792	1.1	1.1
Tensile Properties	ASTM D 882		
Breaking Factor, lb/inch(MD and XD)		50	50
Elongation at break %		400	400
Tear Resistance, lb	ASTM D 1004	9	11
Puncture Resistance, lb	ASTM D 4833	35	60
Low Temperature Brittleness, °F	ASTM D 2137	-49	-49
Seam Properties	ASTM D 413/D 4437		
NSF modified 20 in./min strain rate			
shear strength, lb/inch**		35	35
peel strength, lb/inch***		14	14

*All values, unless specified otherwise, are minimum average roll values as reported for the test method.

** At 200% strain.

*** Cohesive Bond Mode